APPLICATION OF THE INFORMATIONAL REFERENCE SYSTEM "OZHUR" TO THE AUTOMATED PROCESSING OF DATA FROM SATELLITES OF THE "KOSMOS" SERIES

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16 Abstract

In this paper we consider the structure and potential of the information reference system "OZhUR" designed for the automated data processing systems of scientific space vehicles (SV). The system "OZhUR" ensures control of the extraction phase of processing with respect to a concrete SV and the exchange of data between phases. The practical application of the system "OZhUR" is exemplified in the construction of a data processing system for satellites of the "Kosmos" series.

As a result of automating the operations of exchange and control, the volume of manual preparation of data is significantly reduced, and there is no longer any need for individual logs which fix the status of data processing. The system "OZhUR" is included in the automated data processing system "Nauka" which is realized in language PL-1 in a binary one-address system one-state (BOS OS) electronic computer.

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ABSTRACT. In this paper we consider the structure and potential of the information reference system "OZhUR" designed for the automated data processing systems of scientific space vehicles (SV). The system "OZhUR" ensures control of the extraction phase of processing with respect to a concrete SV and the exchange of data between phases. The practical application of the system "OZhUR" is exemplified in the construction of a data processing system for satellites of the "Kosmos" series.

As a result of automating the operations of exchange and control, the volume of manual preparation of data is significantly reduced, and there is no longer any need for individual logs which fix the status of data processing. The system "OZhUR" is included in the automated data processing system "Nauka" which is realized in language PL-1 in a binary one-address system one-state (BOS OS) electronic computer.

I. The Assignments and Purpose of the System "OZhUR"

When obtaining data concerning scientific space experiments, /3* the information about space vehicles (SV) initially enters a ground reception point, and then is processed. The basic informational unit is the data obtained during one communication session with the SV. The number of communication sessions with one SV may amount to hundreds and thousands. Since several SV operate simultaneously, the number of sessions undergoing processing may amount to thousands.

With respect to the technological considerations, the processing includes a specific number of phases (up to ten). Each phase is characterized by the fact that its contents remains constant for the various sessions of any given SV. On the other hand, the transmission sequence of the processing phases and their total number may change depending on the type of SV, as well as on the results obtained in the preceding processing phase [1].

To complete the next processing phase, it is necessary to transmit a definite set of reference data from the preceding phase. The concrete content of these data depends on the phase in which they are being processed.

Thus, in order to perform large-scale processing, a system is necessary which can carry out the following organizational and reference functions:

- registering the incoming sessions and the accompanying data; /4
- registering the progress of processing phases;
- exchanging data between program phases;
- distributing information concerning the situation in the processing system (the number of sessions at any given phase of processing for different SV, the number of fully processed sessions, etc.).

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*Numbers in the margin indicate pagination in the foreign text.

Until recently, all these functions were performed by the person responsible for the processing, who used the logs of the sessions and the progress of the processing phases for each session and also the data which the program phases exchanged.

At the present time, the Institute for Space Research of the Academy of Sciences USSR has developed the automated informational reference system OZhUR [operativnyy zhyrnal upravleniya rabotami ((rapid operational control log)] which is in operation [2].

The system is realized within the framework of a BOS OS electronic computer and is a complex of programs and data banks which are stored on magnetic disks and tapes.

The OZhUR system performs the following functions:

- recording information in the bank of stored data which is presented by a problem-solving program of a given phase;
- distributing data according to the requirements of a problem-solving program;
- organizing a bank of stored data;
- safeguarding a bank of stored data against errors, repeated or incorrect recordings;
- providing information about the filling of data banks and the requirement of new facilities for data storage.

The programs of the "OZhUR" system consist of the basic program which realizes the functions mentioned; auxiliary programs ensuring the initial entry into the system named for a new SV, according to which information began to be admitted; registration in the system of information about a communication session whose data will be processed subsequently; programs for copying data stored in the system on reserve carriers. Moreover, there are service programs with whose help it is possible to obtain data from various sections of a bank of stored data: after a given interval of time a number of sessions are received, the receiving stations on the ground are loaded, there are a number of communication sessions containing

/5

information concerning the playback of the onboard information system, the number and names of the communication sessions which had undergone the given processing phase, the status of data processing for the SV as a whole, etc.

To store a data bank of the "OZhUR" system, magnetic disk and tape storage units are used. Auxiliary, service, and all problem-solving programs operate with data banks on magnetic disks only. To ensure reliability in the storage of data, reserve disks and magnetic tapes are provided, onto which the entire bank of data from the "OZhUR" system is transcribed periodically.

The organization of the data bank makes it possible to introduce necessary corrections into data which has already been stored without imposing a limitation on the number of processing phases completed for each session, and permits the selection of the required volume in the bank in accordance with the name of the SV and the introduction of new volumes if the preceding volumes are completely filled.

All the basic function are fulfilled automatically by the "OZhUR" system. The exclusions are as follows: the stage of initial registration of information concerning a new SV and about a communication session in the system when the data is prepared manually, and specific situations in the system (for example, the requirement that a needed volume be prepared or a communication concerning an attempt to repeat the performance of a processing phase) when the system operates in dialog status with the operator, turning to him for instructions provided by the user. /6

The entire structure of the "OZhUR" programs is written in the PL-1 language of the system BOS OS and is used in the official system of preliminary and initial data processing of the Institute for Space Research of the Academy of Sciences USSR.

II. The Organization of the Data Bank in the "OZhUR" System

According to the technology for processing data from scientific SV which is applied in the Institute for Space Research of the USSR Academy of Sciences, the technologically complete unit in a system or preliminary and initial processing (SPIP) is the information from one communication session received by any ground point of the radiotelemetric system (RTS).

For each such session, a declarator is introduced in the system which defines unambiguously the data file subject to processing. This declarator is called the identifier of the session. It consists of 17 bytes of data and has the following structure:

```
1 IDS CHARACTER(17),
  2 SATNAME CHAR(8),    - the name of the SV
  2 ORBIT CHAR(6),      - number of the session
  2 PART CHAR(1),       - number of the part
  2 REGIME CHAR(1),     - operating regime RTS
  2 STATION CHAR(1)     - number of the receiving station
  2 SPARE CHAR(1)       - spare symbol
```

It should be noted that any unit may appear as SATNAME about which information must be accumulated in "OZhUR". In a modified version of "OZhUR" the catalog of magnetic tapes OS, used in SPIP according to the unit, appears as one of the units.

The operating data of the "OZhUR" system is organized in the form of a log with pages on each of which there is a fixed volume of data. The pages are subdivided into four types, arranged in succession. The capacity of each page of the log is 632 bytes [3]. /7

1. Pages of type 1

Designed to store all the names of SV whose data will be processed. Provision is made for recording the names of new SV. To

the name of each SV there corresponds the number of a magnetic disk where data will be stored by phase, and likewise the number of a reserve magnetic disk needed in case the basic disk overflows. On these pages there is also contained the number of the first blank page in the log with no recorded data, and an indicator of the extent to which the basic magnetic disk is filled. In case of necessity, the operator of the electronic computer will be informed by means of this indicator that the reserve disk should be installed.

2. Pages of type 2

On these pages the index of the log is located. Each page of the index may contain seven session identifiers, and for each of them there are up to seven designations of processing phases. For each session identifier and each phase designation, the number of a type 3 page is specified where the data is contained which was prepared by this phase. If the number of processing phases is greater than seven, then on the page there is a continuation sign for each session identifier which indicates the presence of the following seven processing phases on one of the other pages in the index of the log, etc.

3. Pages of type 3

This type of page is intended for the storage of data prepared by any processing phase of a session with a certain identifier. The /8
structure of these pages corresponds completely to the structure of the array COM described below, with whose aid data is transmitted to the "OZhUR" system.

4. Pages of type 4

On these pages is located the magnetic tape catalog of the electronic computer. This catalog is intended for use in the data processing system.

III. The Basic Program of the "OZhUR" System

The basic program of the "OZhUR" system is called OJUR and is a procedure with three formal parameters: OJUR(IDS,NPR,ACT).

The program is cataloged in the form of subprograms in the unit module library of the system and can be used by any official, service, or problem-solving program.

The formal parameter IDS is a 17 byte row which takes on the meaning of a session identifier in the OJUR program subject to processing.

The meaning of the formal parameter IDS can be assigned in the program inducing the OJUR procedure, as well as from a punched card introduced by the OJUR procedure. In this case, the variable IDS must be assigned the meaning 'INPUT' in the inducing program.

The formal parameter NPR is the six-byte name of a phase whose data must be recorded or scanned. The meaning of NPR must be assigned in the inducing program.

The formal parameter ACT is a two-byte variable of the type CHARACTER. With its aid the operating regime of OJUR is assigned. If ACT='WT' (record), then data prepared by the phase NPR for the session identifier IDS is recorded in OJUR. If ACT='RD' (read), then data of the phase NPR for the identifier IDS is read. If ACT='RW' (rewrite), then a search of the page with the previously recorded data of the phase NPR for the identifier is carried out, and in place of that data the new data prepared by phase NPR is recorded on this page. Thus this regime is used whenever, for any reason whatever, phase NPR is repeated. /9

To transmit data prepared by phase NPR, an array designated COM is used, which is described in the OJUR program as COM(632) CHARACTER(1) EXTERNAL.

In the program of phase NPR, it must be described in the same manner. It must be kept in mind that the 32 first bytes in the file COM are filled during the regimes 'WT' and 'RW' of the program OJUR. In this domain there are recorded:

17 bytes — IDS
6 bytes — NPR
6 bytes — year, month, day, recorded in OJUR
3 bytes — reserve

The remaining 600 bytes can be filled by the NPR program, and they will be transferred without any reduction into OHUR.

If the volume of the data introduced by the program NPR exceeds 600 bytes, it is possible to extract these data sequentially, but here each extraction must be executed with its own unique name. The breakdown of a file into extracted subfiles of the size of COM must be carried out by the program NPR.

IV. The Initial Recording of Data in the OZhUR System

Before the information processed by the communication sessions of some SV is programmed, and in order to have the opportunity to use /10
the OZhUR system for exchanging data from processing phases, a number of formal operations must be performed which are identical for each new SV and new communication session.

After the SV with scientific equipment onboard is launched and the first data has been recorded on magnetic tapes with telemetric information about the operation of the equipment, the name of the new SV together with the number of the magnetic disk on which the data will be contained concerning the processing phases is recorded in the index of the OZhUR system on all its magnetic disks. The basic program of the OZhUR system includes verification of the presence of the space vehicle's name in the index, and it verifies the correctness of the installation of the OZhUR system disk. In case of reference during processing with an incorrect SV name,

and during installation of another disk of the OZhUR system, information is given to the user and to the electronic computer, who in the latter case can take measures to install the required disk.

Information about each communication session become accessible after the identifier of the session is assigned to it, the session is recorded on a punched card, and it is used in the initial data loading program named CHARGE.

The session identifier is set up on the basis of documentation which accompanies the magnetic tape with telemetric information. Use of a punched card with a session identifier in the data of the program CHARGE leads to the recording of this identifier in the index for the magnetic disk of the OZhUR system intended for this SV.

Simultaneously with the recording of the session identifier, the program CHARGE performs the recording of the reference data for this session, such as:

1) the ordinal number of the SV in the processing system; /11
2) the ordinal number of the magnetic tape with telemetric information concerning the given SV;
3) the speed with which data is recorded on the magnetic tape with telemetric information;
4) the date when the communication session was conducted;
5) the entry date of the magnetic tape;
6) the number of operating regimes for the telemetric system of the SV in the given session.

These reference data are also recorded with the help of a punched card placed in the data of the program CHARGE for each session identifier.

In addition to the reference data, the initial loading program CHARGE can perform for each session identifier the recording in OZhUR of the data about the tie-in of the operating regimes of the telemetric system (beginning and ending) to Moscow time, if the data

were obtained from documentation for the session or as a result of manual processing. There is also the possibility of introducing into the system data concerning correlating with Moscow time the moments of nullification of the timer onboard the SV — data which are subsequently used for automatic time correlation.

The program CHARGE has two basic operating regimes:

1) the initial loading of data (the session identifier and the reference data, and information concerning the correlation of the time of regimes);
2) the modification regime.

In the modification regime, the following may be accomplished:

a) recording reference data regarding a session and/or data concerning the correlation of time if these data were not introduced into OZhUR during the initial loading;
b) changing reference data/and/or information concerning the correlation of time if errors were detected in the data or if additional information arrived. /12

Special forms are used in the preparation of the data of the program CHARGE.

V. The Informational-Reference Potentialities of the OZhUR System

The data structure in the system OZhUR described above demonstrates quite well that the system is conveniently constructed and is open for the receipt of such data as the number of SV with respect to which information is being processed, the amount and number of communication sessions with different characteristics (classification with regard to ground receiving stations, operating regimes of telemetric systems, etc.), the amount and designation of the processing phases with respect to each session, information transmitted to each phase, etc.

At the present time, two basic programs have been created to realize the informational-reference potentialities of the OZhUR system.

1. Program WEGOT

This program sorts data recorded in OZhUR, and in various regimes of its operation distributes a printout with the following information:

a) a list of communication sessions in increasing numerical order obtained from all or each ground receiving station separately according to the assigned name of the SV with the number of the magnetic tape, the date of the session and the transmission;
b) the loading table of the ground receiving stations during operation with the SV data.

2. Program SHOW /13

When the name of a SV is specified, this program sorts the contents of the disk of the system OZhUR and prints the tables for the given SV containing:

a) the session identifiers in increasing numerical order of the sessions and the designations of the processing phases performed with respect to each session;
b) a table with the number of sessions which are at each of the processing phases.

With the help of these two programs, the data intake is analyzed for each SV and the day-to-day status of information processing is controlled. Information concerning these programs can be obtained over any desired time interval.

There are also programs to print out information organized and transmitted to OZhUR by a number of sequential phases of data processing.

VI. Interaction of the "OZhUR" System with a Complex of Data Processing Programs from Satellites of the "Kosmos" Series

Processing of data from a scientific space experiment performed by means of a satellite of the "Kosmos" series is accomplished by the system of preliminary processing (SPP) "Nauka". This SPP (realized on a base consisting of an electronic computer) includes four program phases: NAUKA0, NAUKA1, NAUKA2, NAUKA3.

In Figure 1, we present a block diagram of the interaction of each program of the SPP "Nauka" with the informational-reference system (IRS) "OZhUR".

Program interchange through the IRS is accomplished by means of a common array BEGINNING, which is filled after new data necessary for the performance of the next program phase has passed through the routine processing phase. /14

In order for any new program to begin operation, there must be information in the SPP "OZhUR" concerning the successful completion of the preceding phase. To control this, each program introduces a punched card "IDS", standard for all phases, with the name of the unit, the number of the session and its part, and with the operating regime of the RTS.

Then the program is directed to the basic program of SPP which bears the designation "OHUR" in the reading regime (ACT='RD') and with the value of the formal parameter NPR (phase name), corresponding to the name of the previous phase.

If the data from any session (or its part) has not undergone processing by the preceding program, then the SPP gives out the

information that the preceding phase is not in "OZhUR", and the program suspends its realization.

Besides the standard punched card "IDS" and the names of the preceding phase incorporated into all program phases, each program requires additional input data (punched cards, magnetic tapes (MT), magnetic disks (MD), and data from "OZhUR").

As the basic vehicle for scientific telemetric information in the SPP "Nauka", magnetic tapes of an OS electronic computer are used:

- MT ORBIT, on which are recorded the osculating elements of the orbit at the beginning of each turn for the calculation of the satellite's trajectory at any moment of the measurement of scientific parameters;

- MT FPI (fund of primary information), on which are recorded the results of the measurements from physical experiments. These measurements are recorded on special telemetric magnetic tape (MT RTS), not suitable for direct processing on an OS electronic computer. Therefore, all telemetering undergoes a stage of transcription from MT RTS to MT OS EVM (EVM — elektronnaya bychislitel'naya mashina — electronic computer) and consequent careful monitoring of the performance of this operation. This phase is not included in the SPP "Nauka" by virtue of a certain characteristic in its design. As a result, we have in general on MT FPI a multifile volume where each session is a file; /15

- MT RPP (results of preliminary processing), on which a multifile volume is also established where each session is a file;

- MT OZHUR, on which is recorded all necessary data for interchange between preliminary processing programs, and also an exchange of reference information concerning the general status of processing with each concrete satellite of the "Kosmos" series.

The phase "NAUKA0"

As is clear from the block diagram (Figure 1), the program "NAUKA0" is designed to work with data from "OZhUR", the punched card "DNO" and MT ORBIT.

With the help of the punched card "DNO" (data for the program "NAUKA0"), the following are introduced:

- the number of the MT FPI,
- the ordinal number of the session being processed on MT FPI,
- the voltage of the standard battery in millivolts.

From the IRS "OZHUR" the program takes the meanings of the on-board markers, their dates, and the Moscow time, the storage regime (lines 3, 4).

From the MT ORBIT are selected to code of the satellite and the the osculatory elements of the orbit which are closest with respect to time to the beginning of storage of scientific information.

As a result, the program "NUAKA0" activates the array BEGINNING which becomes the common array for all further programs of the SPP "Nauka". In this array, the program fills lines 1 - 7 of "OZhUR" (Figure 1).

On an alphanumeric printer (ANP), the program supplies information about the carrying out of functions and the contents of the common array after the end of a phase. /16

The phase "NAUKA1"

The program "NAUKA1" performs the first step in processing telemetric information. It deciphers data regarding station time and, according to the number of telemetric words between two neighboring station seconds, it determines the limits (in units)

of direct transmission (DT) of data and the reproduction of stored information (SI).

The program for the operation uses the standard punched card IDS, data from "OZHUR" (lines 1, 2) and MT FPI.

In the common array "BEGINNING", the program records the initial and final units of the regimes DT and SI (line 8).

On an ANP the program supplies information concerning a completed assignment, a detailed printout of deciphered station seconds with unit numbers and the bytes in a unit, where its marker is found, and also the number of telemetric words between adjacent seconds.

To monitor the common array, its contents are printed on an ANP.

The phase "NAUKA2"

The "NAUKA2" program structures the distribution of telemetric information according to the levels of the following channels:

- 0% calibrations (one level);
- 100% calibrations (one level);
- standard battery (one level);
- onboard time (two levels).

The table of distributions is produced on an ANP for monitoring the quality of the transcription of telemetric information from MT RTS to MT FPI. This is the first function of the program.

The second function of the program consists in determining the limits of the levels of all channels being studied which are used during subsequent processing. /17

In addition to the punched card "IDS", the program uses data from "OZHUR" (lines 1, 2, 8) and MT FPI.

In the array "BEGINNING", the program records the limits of the levels of calibrating channels, the channel of the standard battery, and the channels of the onboard time (lines 9, 10, 11).

For monitoring, the array is also printed on an ANP.

The phase "NAUKA3"

The program "NAUKA3" performs the following assignments of preliminary processing:

- restoring the standard frame-by-frame structure of telemetric information (a frame is one complete sampling of all telemetric channels). During restoration of the structure, the program is based on the cyclicity of the channel sampling, the layout of the channels, the data concerning the period of the sampling cycles (which is expressed in the length of a frame in telemetric words, and the lengths of the time markings in the frames);

- processing the channel of the onboard time which includes the deciphering of data, the detection and the restoration of malfunctions (where this is possible), checking the sequences of onboard time markers for monotonicity;

- formation of new measurement frames from scientific information (choice of channels);

- tying each frame to Moscow time and date;

- processing data of the calibrating channels (0% and 100%), and averaging them over the given session.

The result of processing (in telemetric codes) is recorded on the magnetic tape MT RPP. /18

To operate the program, the punched card "DN3" (data for the program "NAUKA3") is used, on which is punched:

- the number of the MT RPP,
- the ordinal number of the session being processed on this magnetic tape.

The program "NAUKA3" operates with telemetric data recorded on MT FPI and data of "OZHUR" (lines 1 - 11).

In the array "BEGINNING" the program records certain processing results (lines 12-- 17).

Moreover, certain intermediate processing results are printed on an ANP for visual monitoring, as are also the contents of the array "BEGINNING" which are common for all programs.

The capacity to solve the following additional problems is provided in the program "NAUKA3":

- translation of the level channels into the actual numbers of the levels;
- translation of the continuously changing parameters for dealing with calibrations into volts on the telemetric scale;
- marking out a slowing changing commutator.

So that the program can solve these problems, it is necessary to punch on the perforated card "DN3", after the number of the MT RPP and the ordinal number of the session being processed, a sign denoting the requirement that the problems mentioned be solved (any numeral except zero).

In this case, besides the data from "OZHUR", the program requires that several punched cards be introduced, on which information is recorded about the number of the selected channels and their characteristics: continuity or level, the average value, and the number of levels of the level channels.

BLOCK DIAGRAM OF THE INTERACTION OF THE SPP "NAUKA" AND THE IRS "OZHUR"

1. Number of the MT FPI.
2. Ordinal number of session on MT FPI.
3. Onboard markers for the beginning and ending of storage, their Moscow time and date.
4. Alternative storage (discontinuity of the onboard timer).
5. Voltage of the standard battery in millivolts.
6. Code of the satellite (its ordinal number in the "Kosmos" series).
7. Osculatory elements of the orbit.
8. Initial and final units of the intervals DT and SI on MT FPI.
9. Limits of the limits of the levels of the calibrating channels (0% and 100%).
10. Limits of the level of the standard battery channel.
11. Limits of the levels of the onboard time channels.
12. Number of the MT RPP.
13. Ordinal number of the session on MT RPP.
14. Numer of units in the session.
15. Number of telemetric frames in the session.
16. Number of malfunctioning frames in the session.
17. Date and time of the first and last frame in the session.

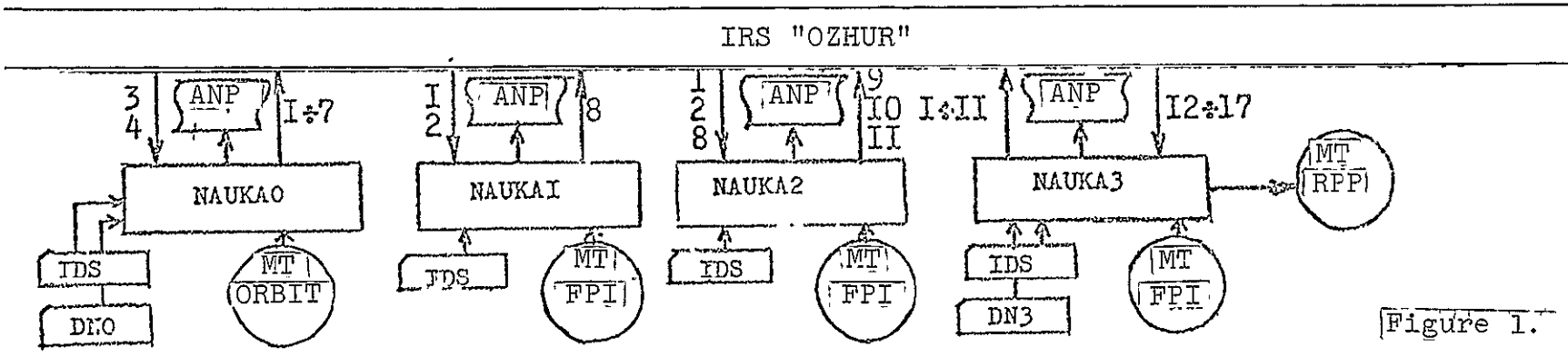

Figure 1.

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